Implied Cognitive Demand and Depth of Knowledge

A fundamental criterion used to develop the NECAP GLEs and GSEs is that the expectations should explicitly indicate cognitive demand (how content interacts with process) and that there should be a mix of cognitive demand levels at all grades. One should not assume that students at lower grades do less cognitively demanding work. The cognitive demand or depth of knowledge required by an expectation or an assessment item is related to the number and strength of connections of concepts and procedures that a student needs to make to produce a response, including the level of reasoning required along with self-monitoring. Furthermore, there are additional factors that influence cognitive demand including contextual requirements, language, the number and variety of representations, requirements for generalizations to new situations, and the opportunity to learn.

It is important to note that depth of knowledge is not synonymous with difficulty. As an example, solving a multi-step linear equation with variables on both sides may be a difficult task for middle school students; however, the task can be solved by applying a standard procedure making the task of low complexity.

The NECAP states believe that expectations and assessments should be aligned in terms of their cognitive complexity. That is, the cognitive complexities of the assessment items should match those of the standards (what students are expected to know and be able to do). To ensure this alignment, the NECAP states have adopted Norman L. Webb's (senior researcher with the Wisconsin Center for Educational Research) Depth of Knowledge classification system. Norman Webb's system is based on four levels of classification. The full descriptions of each level are given on pages 4 and 5. The levels can be summarized as follows.

Level 1	Recall
Level 2	Skill/Concept
Level 3	Strategic Thinking
Level 4	Extended Thinking

The NECAP states, together with a committee of educators, analyzed the GLEs and GSEs for their implied cognitive demand. All aspects of each expectation were analyzed and the implied cognitive demand levels were recorded. One of the charges of the NECAP test item review committees is to ensure that assessment items align not only with the expectations but also with their implied cognitive demands. The range of cognitive demands for each GLE and GSE is summarized in Table 1. It should be noted that the highest level listed for each GLE and GSE should be thought of as a "ceiling" not a "target". A NECAP goal is to write items that cover the range of the levels indicated and not just the highest level. If one assesses only at the "target" level, all GLEs with a level 3 (for example) as their "ceiling" would only be assessed at level 3. This would potentially have two negative impacts on the assessment: 1) The assessment as a whole would be too difficult, and 2) important information about student learning along the achievement continuum would be lost. To the extent possible, each GLE and GSE should be assessed at the "ceiling" and at least one level below the "ceiling" in order to provide additional diagnostic information to educators. Furthermore, Table 2 shows an example of an expectation and how the different aspects of the expectation interact with Table 1.

Table 1: NECAP Mathematics Depth of Knowledge Ranges*

	Depth of Knowledge Levels for NECAP Assessment						
	2	**3**	**4**	**5**	**6**	**7**	**10**
M(N&O)–X–1	1, 2	1, 2	1, 2	1, 2	1, 2	1, 2	
M(N&O)–X–2	1	2	2	2	2	2	1, 2, 3
M(N&O)–X–3	1, 2	2	2	2,3	2,3		
M(N&O)–X–4		1, 2, 3	1, 2, 3	1, 2, 3	1, 2, 3	1, 2, 3	1, 2, 3
M(N&O)–X–5	1, 2						
M(G&M)–X–1	1, 2, 3	1, 2	1, 2	1, 2	1, 2		
M(G&M)X–2						1, 2	1, 2, 3
M(G&M)–X–3			1, 2	1, 2	1, 2		
M(G&M)–X–4				1, 2		1, 2	2, 3
M(G&M)–X–5			1, 2		1, 2	1, 2, 3	1, 2, 3
M(G&M)–X–6	1, 2	1, 2	1, 2	1, 2	1, 2, 3	1, 2, 3	1, 2, 3
M(G&M)–X–7	1, 2	1, 2	1, 2	1, 2	1, 2	1, 2	1, 2
M(G&M)–X–8							
M(G&M)–X–9							2, 3
M(F&A)–X–1	2	2	2	2	2, 3	2, 3	2, 3
M(F&A)–X–2					1, 2	1, 2	1, 2
M(F&A)–X–3			1	1	1, 2	1, 2, 3	1, 2, 3
M(F&A)–X–4	1	1, 2	1, 2	1, 2	1, 2	1, 2	1, 2, 3
M(DSP)–X–1	1, 2, 3	1, 2, 3	1, 2, 3	1, 2, 3	1, 2, 3	1, 2, 3	2, 3
M(DSP)–X–2	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3
M(DSP)–X–3		1, 2		1, 2		2, 3	1, 2, 3
M(DSP)–X–4	2		2, 3		2, 3		1, 2, 3
M(DSP)–X–5		1, 2	1, 2	1, 2	1, 2, 3	1, 2, 3	1, 2, 3

Black cells indicate GLEs or GSEs that are not assessed on NECAP at the given level.

*Test item review committees consider contextual requirements, language, the number and variety of representations, requirements for generalizations to new situations, and the opportunity to learn when making decisions regarding the depth of knowledge levels of items. Therefore, it may be the case that a particular item is coded with a depth of knowledge level that falls outside of the range indicated in Table 1.

Table 2: Depth of Knowledge Range Example

Sample Mathematics GLE* for End of Grade 6	Potential DoK Levels	DoK Ceiling	Aspects of GLE at different levels**
M(F&A)–6–1 **Identifies and extends to specific cases a variety of patterns** (linear and nonlinear) represented in models, tables, sequences, graphs, or in problem situations; or writes a rule in words or symbols for finding specific cases of a linear relationship; or writes a rule in words or[sc] symbols for finding specific cases of a nonlinear relationship; and writes an expression or[sc] equation using words or[sc] symbols to express the **generalization** of a linear relationship (e.g., twice the term number plus 1 or[sc] $2n + 1$).	**2, 3**	**3**	**Level 2** Extends a pattern to a specific case **Level 3** Generalizes a pattern

*GLE NOTES: Underlining in the GLE indicates that this concept or skill is "new" to grade 6 for assessment purposes. The superscript "sc" indicates that students have a choice in how they complete the task (e.g., students can use words **or** symbols to express the rule).

** This table serves as an example of how the ranges identified in Table 1 interact with different aspects of a GLE and does not indicate, for example, that extending a pattern to a specific case is always coded as a level 2 item. One must consider many factors when making decisions on Depth of Knowledge levels such as contextual requirements, language, the number and variety of representations, requirements for generalizations to new situations, and the opportunity to learn.

Depth of Knowledge Descriptors for Mathematics

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Mathematics Depth of Knowledge Levels

Level 1 (Recall) includes the recall of information such as a fact, definition, term, or a simple procedure, as well as performing a simple algorithm or applying a formula. That is, in mathematics a one-step, well-defined, and straight algorithmic procedure should be included at this lowest level. Other key words that signify a Level 1 include "identify," "recall," "recognize," "use," and "measure." Verbs such as "describe" and "explain" could be classified at different levels depending on what is to be described and explained.

Level 2 (Skill/Concept) includes the engagement of some mental processing beyond a habitual response. A Level 2 assessment item requires students to make some decisions as to how to approach the problem or activity, whereas Level 1 requires students to demonstrate a rote response, perform a well-known algorithm, follow a set procedure (like a recipe), or perform a clearly defined series of steps. Keywords that generally distinguish a Level 2 item include "classify," "organize," "estimate," "make observations," "collect and display data," and "compare data." These actions imply more than one step. For example, to compare data requires first identifying characteristics of the objects or phenomenon and then grouping or ordering the objects. Some action verbs, such as "explain," "describe," or "interpret" could be classified at different levels depending on the object of the action. For example, if an item required students to explain how light affects mass by indicating there is a relationship between light and heat, this is considered a Level 2. Interpreting information from a simple graph, requiring reading information from the graph, also is a Level 2. Interpreting information from a complex graph that requires some decisions on what features of the graph need to be considered and how information from the graph can be aggregated is a Level 3. Caution is warranted in interpreting Level 2 as only skills because some reviewers will interpret skills very narrowly, as primarily numerical skills, and such interpretation excludes from this level other skills such as visualization skills and probability skills, which may be more complex simply because they are less common. Other Level 2 activities include explaining the purpose and use of experimental procedures; carrying out experimental procedures; making observations and collecting data; classifying, organizing, and comparing data; and organizing and displaying data in tables, graphs, and charts.

Mathematics Depth of Knowledge Levels continued

Level 3 (Strategic Thinking) requires reasoning, planning, using evidence, and a higher level of thinking than the previous two levels. In most instances, requiring students to explain their thinking is a Level 3. Activities that require students to make conjectures are also at this level. The cognitive demands at Level 3 are complex and abstract. The complexity does not result from the fact that there are multiple answers, a possibility for both Levels 1 and 2, but because the task requires more demanding reasoning. An activity, however, that has more than one possible answer and requires students to justify the response they give would most likely be a Level 3. Other Level 3 activities include drawing conclusions from observations; citing evidence and developing a logical argument for concepts; explaining phenomena in terms of concepts; and using concepts to solve problems.

Level 4 (Extended Thinking) requires complex reasoning, planning, developing, and thinking most likely over an extended period of time. The extended time period is not a distinguishing factor if the required work is only repetitive and does not require applying significant conceptual understanding and higher-order thinking. For example, if a student has to take the water temperature from a river each day for a month and then construct a graph, this would be classified as a Level 2. However, if the student is to conduct a river study that requires taking into consideration a number of variables, this would be a Level 4. At Level 4, the cognitive demands of the task should be high and the work should be very complex. Students should be required to make several connections—relate ideas *within* the content area or *among* content areas—and have to select one approach among many alternatives on how the situation should be solved, in order to be at this highest level. Level 4 activities include designing and conducting experiments; making connections between a finding and related concepts and phenomena; combining and synthesizing ideas into new concepts; and critiquing experimental designs.

References

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